Ecological Flows Science Advisory Board

Meeting Summary - **November 15, 2011**

Wake County Ag Center, Raleigh NC

X	APPROVED for distribution 1/31/12

Attendance

Members

Donnie Brewer, EMC
Mark Cantrell, US Fish & Wildlife Service
Bob Christian, NC Marine Fisheries Commission
John Crutchfield, Progress Energy Carolinas
Tom Cuffney, US Geological Survey
Linda Diebolt, Local Governments
Chris Goudreau, NC Wildlife Resources Commission
Jeff Hinshaw, NC Cooperative Extension (online)
Jim Mead, NC Division of Water Resources
Sam Pearsall, Environmental Defense
Judy Ratcliffe, NC Natural Heritage Program
Jaime Robinson, NCAWWA-WEA
Jay Sauber, NC Division of Water Quality

Alternates

Jessi Baker, NC Division of Marine Fisheries
Cat Burns, The Nature Conservancy
Peter Caldwell, USDA Forest Service
Sarah McRae, US Fish and Wildlife Service
Steve Reed, NC Division of Water Resources
Vann Stancil, NC Wildlife Resources Commission
Fred Tarver, NC Division of Water Resources

NC Division of Water Resources

Don Rayno
Sarah Young

Guests:

Craig Bromby
Kyle Hall, Charlotte/Mecklenburg Stormwater
Lars Hanson, TJCOG
Haywood Phthisic, LNBA
Jason Robinson
Michelle Schimizzi, NCDWQ
Mary Davis, TNC/SARP
Jennifer Phelan, RTI

NCSU Cooperative Extension Facilitation Team

Mary Lou Addor, Natural Resources Leadership Institute (NRLI)
Patrick Beggs (WECO) Watershed Education for Communities and Officials
Christy Perrin (WECO) Watershed Education for Communities and Officials
Nancy Sharpless, Natural Resources Leadership Institute (NRLI)

The purpose of the Ecological Flows Science Advisory Board:

The Ecological Flows Science Advisory Board will advise NC Department Environment and Natural Resources (NCDENR) on an approach to characterize the aquatic ecology of different river basins and methods to determine the flows needed to maintain ecological integrity.

Presentations, reports, and background information about the E-Flows SAB are available at: www.ncwater.org/sab

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EFSAB will meet January 17, 2012 - 12:30 - Archdale Building, Raleigh

Decisions made:

- DWR will give an update on the status of the EFSAB in January.
- The EFSAB charge will be discussed in February.

Nov 15, 2011Meeting Agenda and Summary Table of Contents

I. Executive Summary (Exec Summ added by facilitators Feb. 2013)

Meeting purpose:

To learn about scientific methods that other states/agencies (FL, GA, MI, Potomac River Commission) are using to determine ecological flows; to consider invertebrate issues about habitat suitability curves, and to better understand how ecological flows would be applied to NC River Basin models.

Presentation:Environmental Flow Science - Lessons Learned from Selected Environmental Flow Programs (Mary Davis)

http://www.ncwater.org/Data_and_Modeling/eflows/sab/presentations/20111115/
Mary Davis, technical advisor of the Southern Instream Flow Network at the Southeast Aquatic Resources Partnership gave a presentation about how other states are working to meet the needs of ecological flow requirements. The presentation included:
1) 3 science based methods to determine instream flow needs, and gave examples of these methods being used:

A. Instream Flow Incremental Method (IFIM)- Michigan (IFIM/ELOHA approach)
B. Ecologically Sustainable Water Management (ESWM)- Savannah River, Georgia
C. Ecological Limits of Hydrologic Alteration (ELOHA)- Potomac River Commission Watershed Assessment S

She also described a Presumptive Flow Standard that they published as a conservative approach to protect the natural flow- 80% of daily flows will maintain good ecological integrity in most rivers. A high % of flow (90%) may be needed to protect excellent ecological condition in most rivers.
2) Methods used by select states to determine IF needs (FL, MI, Potomac River Commission)
3)IF resources for NC

A 2 page summary of instream flow program case studies was provided to the EFSAB.

Questions, Comments, and Concerns Raised

- Fidelity may be to something other than class, like physiographic regions (MI is example of how to find relationship)

Proposed Actions or Identified Decisions to be made: none.

Presentation: Invertebrate traits: Compilations of biological characteristics useful for PHABSIM and ecological flow studies (Tom Cuffney)

Tom discussed issues about Habitat Suitability Curves (HSCs) in relation to invertebrate traits. These included scale, taxonomic resolution, surrogates, and relevance to the session law. He presented key questions for the EFSAB, including:

- Should quality of the ecological information (HSC) match the quality of the hydrology and habitat characterization?
- Do we examine similar guilds/taxa/functional groups across sites (ignore differences among streams)?
- Do we emphasize the commonalities or the differences? Might lead to transferability issues.
- Examine important guilds/taxa/functional groups in each stream (include differences among streams)?

Questions, Comments, and Concerns Raised

- There is bigotry about which species are of focus- those we know a lot about and can see.
- What resolution is needed to meet basinwide planning (to raise red flags when water will be overallocated)?
- We have to have some yardstick to measure resilience (is typically a species count).
- Getting ecological flows in place relatively quickly at low cost may be a higher priority than better articulating invertebrate taxa.
- Possible ways to investigate invertebrates further include developing preference curve for specific invertebrates, or compositing the 3 EPT curves to examine the results

Proposed Actions or Identified Decisions to be made:

- EFSAB

Decisions and Recommendations : None

How Ecological Flows Would be Applied to NC River Basin Models (Steve Reed)

http://www.ncwater.org/Data_and_Modeling/eflows/sab/presentations/20111115/Steve_Reed.pdf

Steve Reed, NCDWR, presented on how ecological flows would be used as a screening tool to flag locations where offstream demand and instream eco-flow needs cannot be met under existing or projected conditions. His hypothetical situation used the towns of Tarheelia, Wolftown, and Devilville.

Questions, Comments, and Concerns Raised

- Should EFSAB recommend a presumptive standard as a placeholder for ecological flows in the river basin models since there is nothing yet to represent ecological flows(as suggested by Mary Davis)?
- River basin models need to identify the yield inadequate to meet all needs, essential water uses and ecological integrity.
- The legislation doesn't require one particular model to do this work- it can be multiple models.

Proposed Actions or Identified Decisions to be made:

- At next meeting, NCDWR should provide a mid-term presentation on what is needed from EFSAB

Decisions and Recommendations : None

II. Welcome, Agenda Review Introductions, Logistics

Christy Perrin welcomed everyone to the 9th meeting of the NC Ecological Flows Science Advisory Board. Introductions were made by all attending, in person and online.

The 2012 meeting dates are:

Jan 17	May 29	Sept 25
Feb 21	Jun 19	Oct 23
Apr 24	Aug 28	Nov 27

The facilitation team is working to find additional meeting locations to accommodate the Board's needs. Christy proposed starting at noon and going through 4:30 to give the Board an extra half hour of time. Comments included:

- I would rather condense our meetings into less time.
- I would rather go from 10-2
- What about having longer meetings, all day for example?
- We should start at noon.

For January we will meet 12:30 – 4:30 at the Archdale Building.

A midcourse assessment was requested from DWR.

A public listserv is available. Details for subscribing can be found on the project website: www.ncwater.org/sab

Focused Questions to Guide Discussion

Christy introduced questions from the "Focused Conversation" method by the Institute of Cultural Affairs, to help the Board work through presentations and discussion in an efficient and effective manner. The facilitation team will strive to use these questions to help guide discussion.

1. Clarification- the facts
   What questions of clarification do you have?
2. Reflective- emotions, associations
   What is your reaction to the material/methods presented?
3. Interpretative- insights
   What are the implications for EFSAB's work?
4. Decisional- next steps
   How can we use this information going forward?

III. Review September & October Meeting Summaries

The September 20, 2011 meeting summary was approved at the meeting. The October 18, 2011 meeting summary is still being reviewed and will be approved by email and then placed online. [Note: Both of these meeting summaries were approved and are available online at: www.ncwater.org/sab]

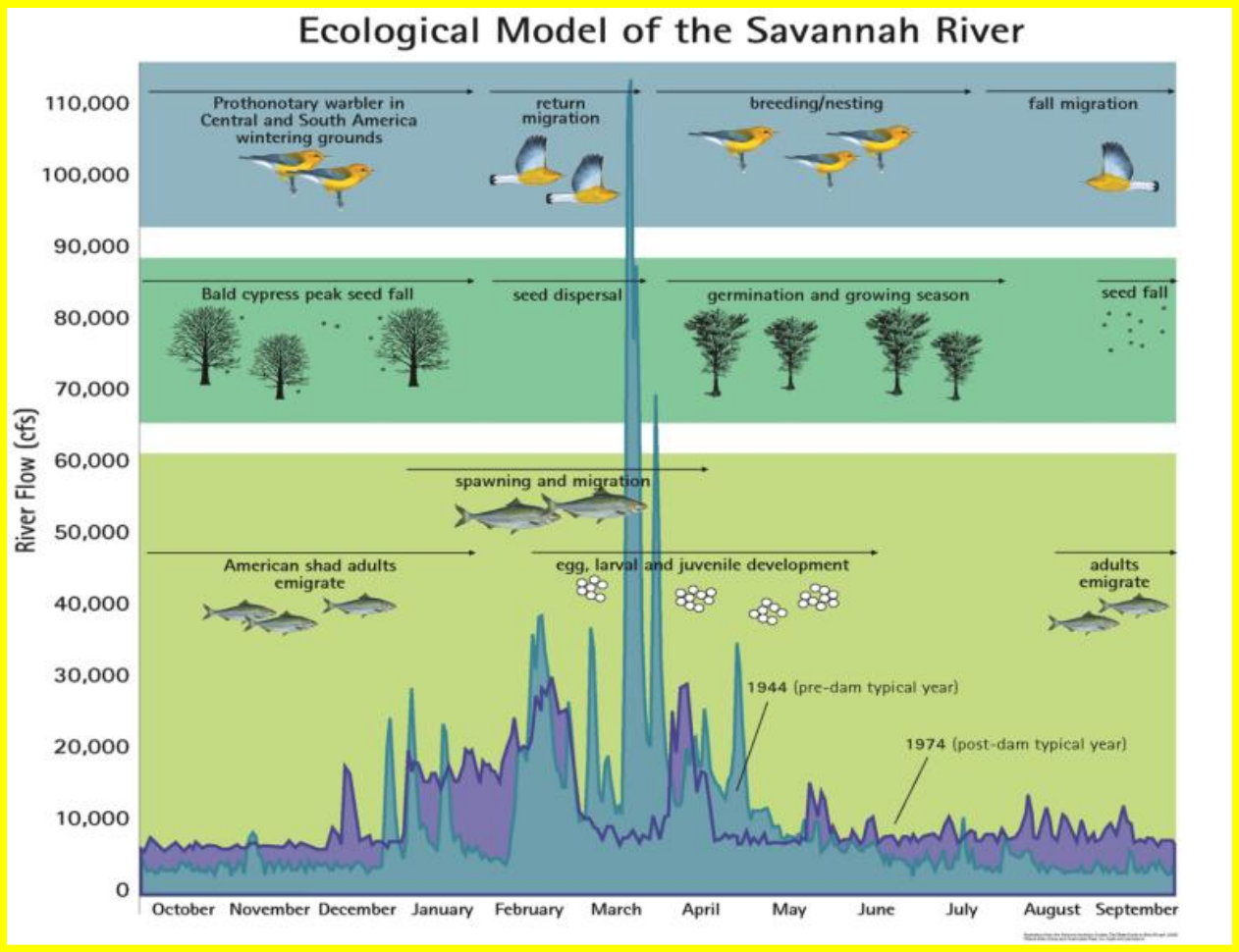
IV. Mary Davis: Environmental Flow Science - Lessons Learned from Selected Environmental Flow Programs

Mary Davis, technical advisor of the Southern Instream Flow Network at the Southeast Aquatic Resources Partnership gave a presentation about how other states are working to meet the needs of ecological flow requirements.

Mary's presentation can be found online in pdf format. Also, you can listen to Mary's presentation by webinar recording online at www.ncwater.org/sab. It starts at 17 minutes in to the webinar.

The purpose of the Southern Instream Flow Network is to facilitate protective instream flow policies and practices in 15 southern states by providing science-based resources and opening lines of communication. More information can be found at: www.southeastaquatics.net/programs/sifn .

The state of the science has clearly established that the natural flow regime (including natural variability among seasons and years) is very important as it shapes riverine systems. When we change the flows, as in the purple hydrograph below, it changes the ecology, for example for inundation and seed dispersal, and upstream movement of fish. We've got the science. The trick is getting that into policy.



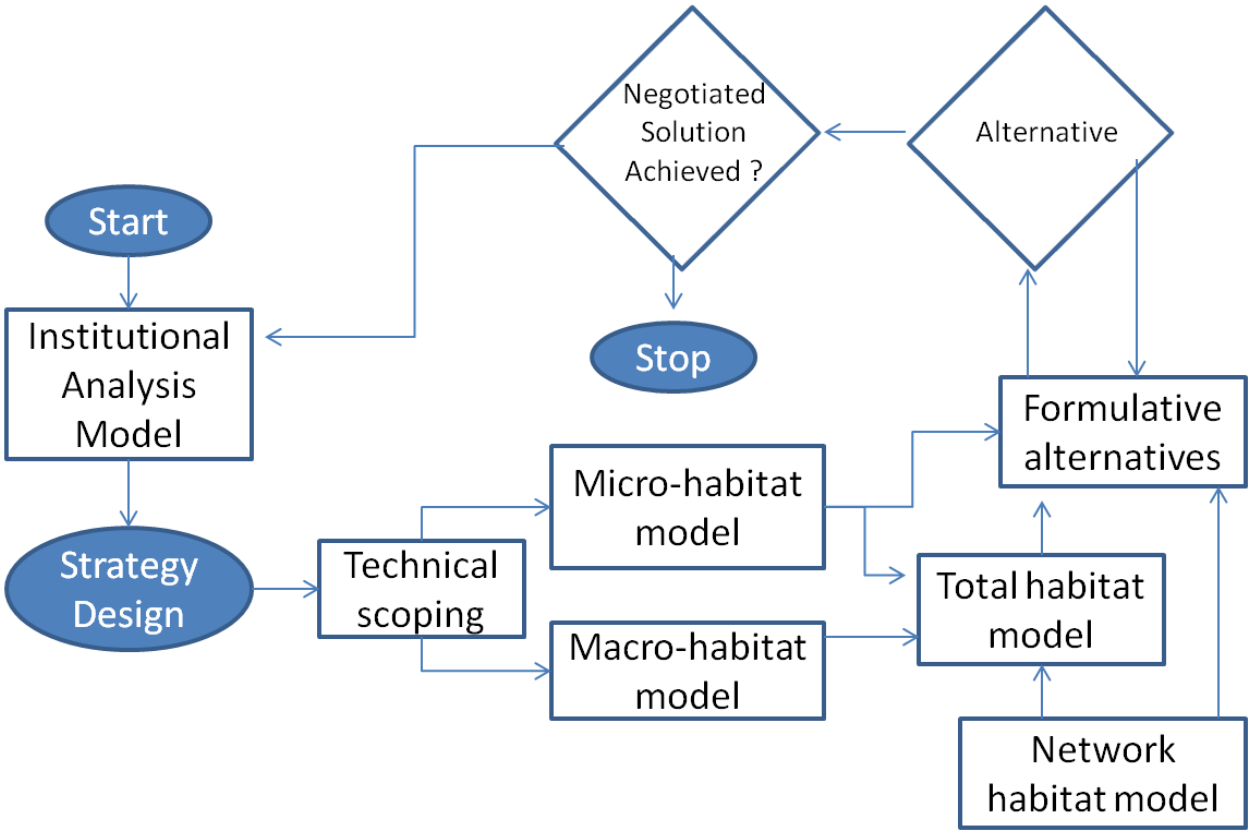
Presentation overview:

1. [review of] **Science based methods to determine IF needs**
2. **Methods used by select states to determine IF needs**
3. **IF resources for North Carolina**

1. Science based methods to determine IF Needs

D. Instream Flow Incremental Method (IFIM)
E. Ecologically Sustainable Water Management (ESWM)
F. Ecological Limits of Hydrologic Alteration (ELOHA)

A. Instream Flow Incremental Method (IFIM)



This is the oldest, most well established method for determining environmental instream flow needs. It is usually applied to site-specific scales with change in habitat as the measure to evaluate alternative water management scenarios. It is the method of choice for NC. Alternatives are the various methods of setting instream flow standards. It illustrates the interplay between science and stakeholders as the solution is negotiated.

It includes field measurements and species-specific habitat models used to estimate the amount of physical habitat available under different flow regimes. An important point to note- there is always a negotiated solution that is a balance between ecological and human uses. Water management alternatives are the basis for a negotiated solution- some things benefit from the water management alternatives and some do not.

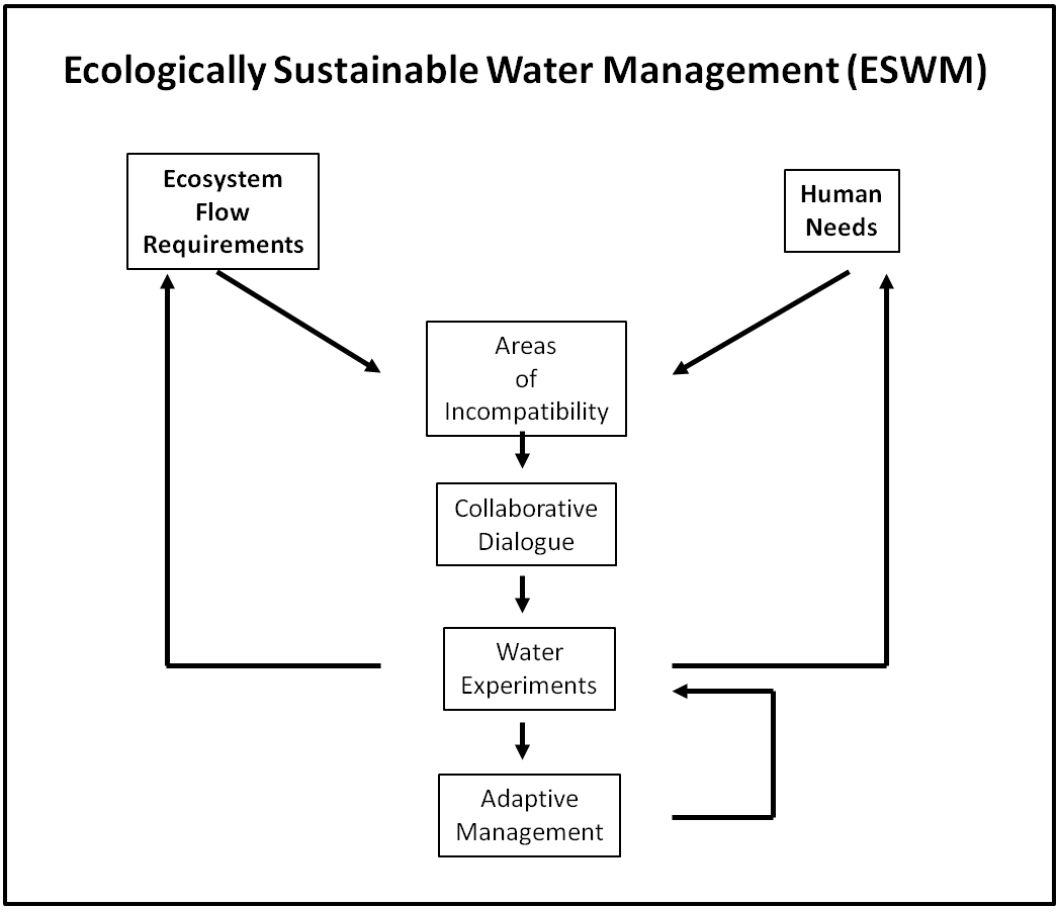
IFIM generates a variety of responses to these water management alternatives. IFIM uses habitat suitability curves based on natural flow variability.

IFIM essentials:

- Well-established methodology developed in the 1970s and 1980s
- Applies (usually) species-specific models at site-specific level
- Based on ***population responses to natural variation*** in velocity, depth, cover, and area
- Negotiated instream flow solutions

B. Ecologically Sustainable Water Management (ESWM)

- Define ecosystem flow requirements - develop initial numerical estimates of key aspects of river flow necessary to sustain native species and natural ecosystem functions;
- Determine the influence of human activities - accounting for human uses of water, both current and future, through development of a computerized hydrologic simulation model that facilitates examination of human-induced alterations to river flow regimes;
- Identify areas of incompatibility - assessing incompatibilities between human and ecosystem needs with particular attention to their spatial and temporal character;
- Search for collaborative solution - collaboratively searching for solutions to resolve incompatibilities;
- Conduct water management experiments - design and implement water management experiments to resolve critical uncertainties that frustrate efforts to integrate human and ecosystem needs; and
- Design and implement an adaptive management plan - using the knowledge gained in steps 1-5, create an adaptive management program to facilitate ecologically sustainable water management for the long term.
- Used to develop ecological flow regimes.

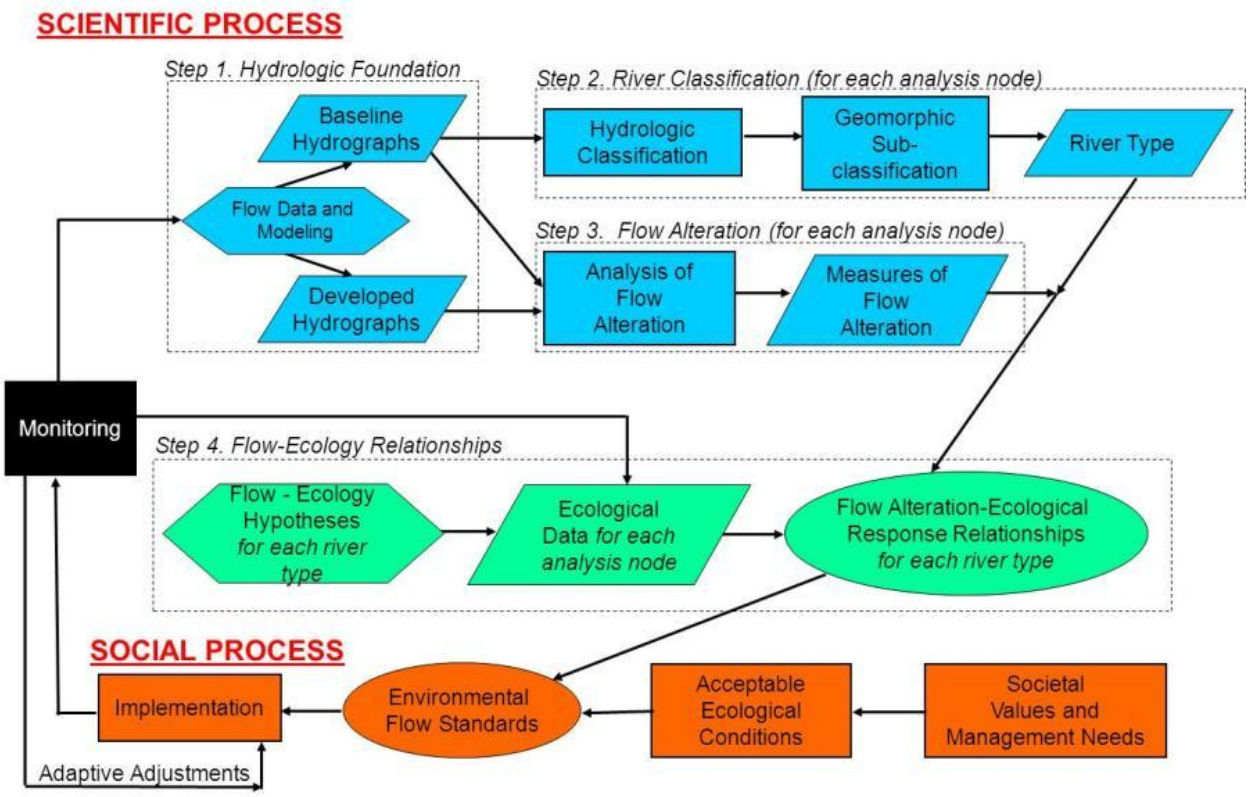


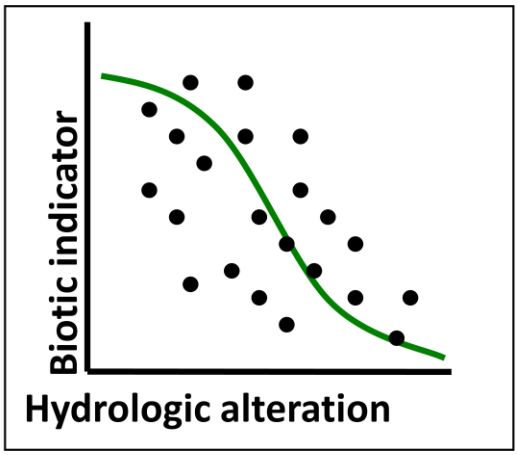
ESWM Essentials:

- Developed in 1990s by The Nature Conservancy
- Applied at watershed level to improve flow regimes and restore ecological function
- Based on existing data and expert knowledge of ecological relationships with natural hydrologic regimes
- Integrates societal values with ecological needs

Mary used the Savannah River in Georgia as an example of the ESWM process.

C. Ecological Limits of Hydrologic Alteration (ELOHA)





- The most recent of the processes
- Developed by 19 national and international flow regime researchers and ecologists.
- The concept is to have the science develop to support the social process.
- Baseline flows are identified and a comparison is performed between baseline and current conditions.
- The idea is to develop some testable hypotheses to test how the ecology will change if you change the flow.
- Y axis is a measure of some ecological health (biotic indicator)
- X axis is a measure of flow alteration (e.g.,- frequency of high flows, magnitude of August median)
- For IFIM, there would be a similar Y axis but the X axis on IFIM would be flow frequency (versus flow alteration which is a measure of flow frequency differences.) This is one of the big differences between ELOHA and IFIM.

ELOHA Essentials:

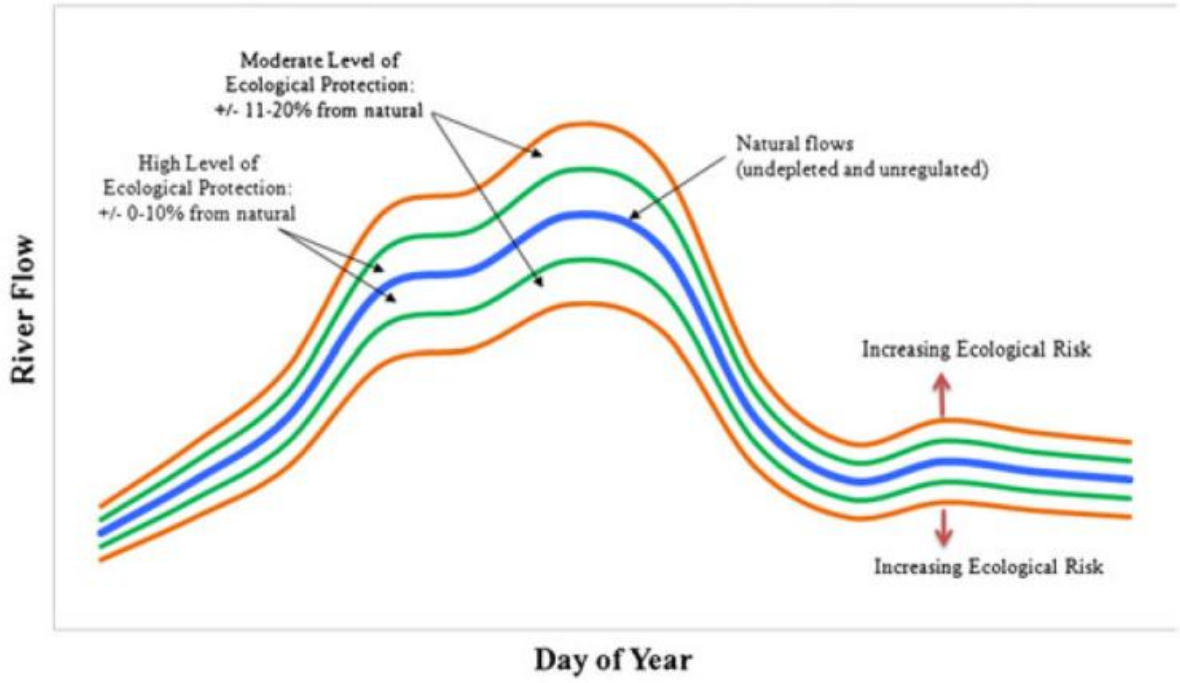
- Newly established method (Poff et al. 2010)
- Uses existing data to develop flow-ecology relationships for classes of rivers
- Based on ***ecological responses to flow alteration*** of natural hydrologic regime
- Integrates societal values with ecological values

Mary used the Potomac River Commission Watershed Assessment as an example of ELOHA, and Michigan as an example of an IFIM/ELOHA approach.

Another method to establish instream flow is to use the available literature.

Mary briefly discussed the work of Ryan McManamay, who recently completed his doctoral work at Virginia Tech, and has done work for SARP under Mary's direction. He looked for ecological responses to flow alteration, focusing on management of dams, with a literature review focusing on the Southeast. He reviewed 180 sources, and found that ecology predominately responded negatively to departures from natural flows. He wrote a number of papers. Mary commented that the research didn't discuss how the flow changes. She also was surprised that the relationship was so strong. The paper, "Ecological Responses to Flow Alteration in the South Atlantic Region, 2011" has been posted at www.ncwater.org/sab > Documents > Ecological Response to Flow Alteration

Presumptive Flow Standard for Environmental Flow Protection



We've seen that it takes a long time to establish the science to develop ecological flows. So we published a presumptive flow standard (Richter et al. 2011). This is using the science we have today, for now. Presumptive flow standard is a conservative approach to protect the natural flow. The assumption is: the further you get away from the natural (blue line) the worse it is for environment. Up to 10 % change is protective; 11% -20% is moderate protection, and requires more study.

We suggest that protecting 80% of daily flows will maintain good ecological integrity in most rivers. A high percentage of flow (90%) may be needed to protect excellent ecological condition in most rivers.

You may want to put presumptive flow standards on your list to discuss.

2. Methods used by selected programs to determine IF needs

Approaches for Determining IF Standards

- Minimum flow threshold
  - 7Q10 (e.g., AL, LA, MS). Note that 7Q10 was developed for pollution dilution, not ecological protection.
  - Modified Tennant (e.g., AR, GA, SC)
  - Thresholds do not reflect natural variability.
- Statistically based standards. Often reflect components of the flow regime. Often useful for dam releases, etc.

(e.g., FL St Johns WMD, Potomac River Commission used ESWM to come up with statistic descriptions)
    - Recognizes need to reflect ecological flows
- Percent of flow approaches (e.g., FL SW Florida and Suwannee River WMDs, TN Presumptive WQ Standard)
    - Alternative scenarios Jim Mead has presented include percent of flow
- TX, NC, VA are currently under development

Instream Flow Methods used by select programs:

- Florida
- Michigan
- Potomac River Commission

Florida:

- The **minimum flows and levels (MFL)** for a given watercourse shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area. The term was used before the term ecological flows was used.
- A MFL is set by the Water Management Districts for each of their priority streams, rivers, lakes, and aquifers.
- Each Florida water management district establishes MFL based on their priorities for protection, using their own methods.

MFLs are used in

- water management allocation planning,
- surface and groundwater withdrawal permit conditions, and
- recovery plans for "over" allocated resources.

SWFWMD Instream Flow Program (Southwest Florida Water Management District)

- Building Block Method
- PHABSim-style methodology
- Percent of Flow Reduction Approach
- 'Significant Harm' threshold = 15% reduction in available habitat for most conservative target, set in the FL legislation. They defined significant harm as 15% reduction in available habitat for most conservative target. (It is a compromise, since ecologists would prefer 10% and developers would prefer 20%. It actually went to court and stood up, since it was a peer reviewed process and it was hard to poke holes in it.)

SFWMD MFL includes:

- Physical Habitat Simulation System, including depth, velocity, and substrate
- Long-Term Inundation Analysis
- Low Flow Threshold - Wetted Perimeter
- Low Flow Threshold - Fish Passage

Resulting in a Flow Prescription which is a Percent of Flow and Seasonality of allowable cumulative withdrawals. It uses the best available information and a peer reviewed process. Although SWFWMD does not classify their rivers, a review of the MFLs set on medium sized coastal rivers shows a fairly consistent range of threshold values.

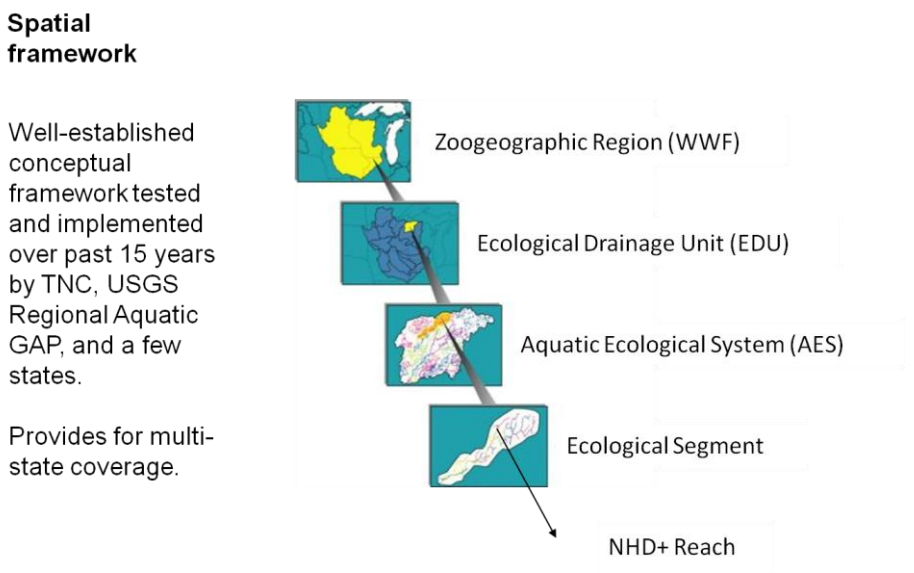
SWFWMD MFL Essentials

- MFL set for each water body (i.e., no classification needed)
- Flow requirements based on most sensitive ecological response to flow alteration (i.e., fish, coarse woody debris, floodplains, organic soils, etc.)
- Estimate habitat loss based on cumulative depletion of the natural daily flow regime
- MFLs for medium size, coastal rivers show a small range of allowable depletions.

Michigan:

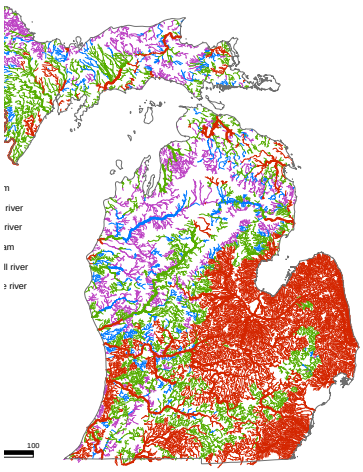
- Protection of environmental flows motivated by the 2001 Annex to the Great Lakes Charter among the states and provinces of the basin. No significant adverse impacts from individual or cumulative actions on water quantity or quality on the waters or water-dependent natural resources of the basin.
- MI defined adverse resource impact as the inability to support 'characteristic fish populations'
- Groundwater is primary water source.
- The 11 river classes are based on flow and temperature, developed by The Nature Conservancy.
- MI rivers can be compared with other rivers globally.
- Stakeholders were asked how much they were willing to give up in their riverine systems. They said they were willing to give up a 10% loss in fish. So when that 10% was related across to other things, they determined what they could withdraw, etc. resulting in the allowance of 50% of the mean August flow to be withdrawn.
- A screening tool is available online for applicants to use.

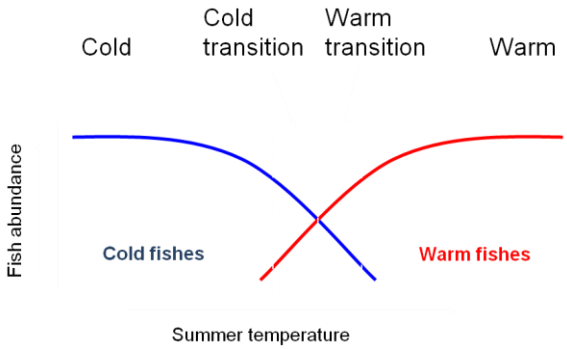
Michigan River Classification Approach



Reach attribution: Key landscape and riverine attributes for every reach came from existing map-level data and state-level models. Examples: flow, temperature, slope, and elevation.

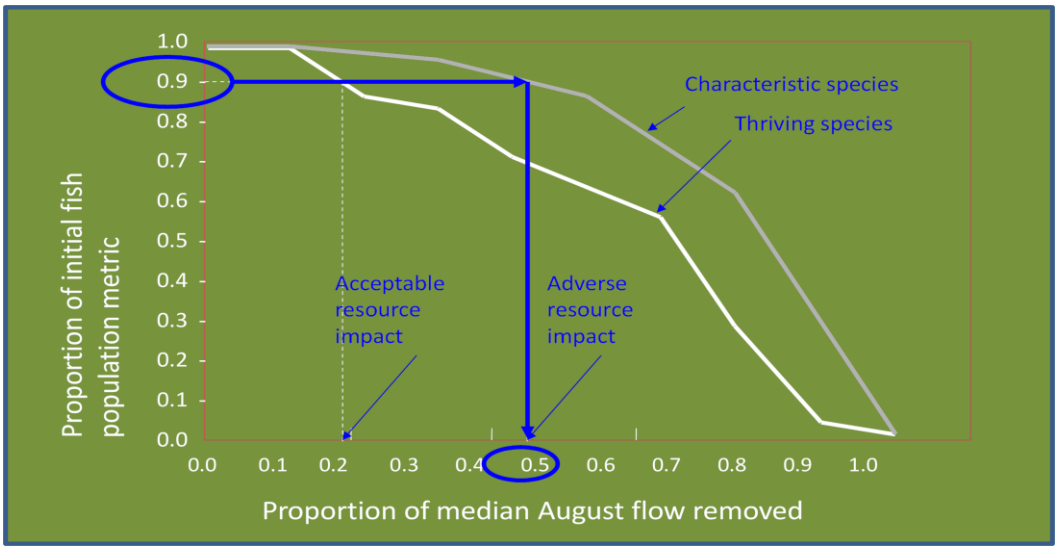
MI fisheries classification is based on temperature. The map is simple and familiar. It is incredibly powerful in policy development. In Michigan it is the "map that changed the world." It is central to state water law and in the minds and language of policy leaders and users. It is useful to many other river management programs.





Michigan Instream Flow Program

- River classification informed by fish assemblages
- PHABSim-style methodology
- For 15 representative sites per river type: Considered initial "characteristic" species, then ran withdrawal simulations and developed scores
- Variation in fish assemblage response curves resulted for each of 15 representative sites within one river type. The mean response was used in the water management program, and policy safeguards were used in recognition of the degree of variation.
- Summaries of simulations create early warning and total impact curves (for assemblage)
- Percent of Flow Reduction Criteria is used



Question: Applicants have to register withdrawals to capture cumulative flows?
Response: Yes.

Q: [Michigan work] was modeled, right?
R: Yes, it was not measured in the field. IFIM is a well-established and respected process globally. Assumptions have been tested.

Potomac River Commission

Middle Potomac Watershed Assessment: Environmental Flows

- Follows ELOHA framework
- Multistate watershed. Study area comprises approximately 11,500 sq. miles of the 14,670 sq. miles of the entire Potomac watershed including parts of four states, MD, PA, VA, WV and all of the District of Columbia.
  *Note: the official study area does not include the North Branch. Recognizing, however, that flow from the North Branch watershed is an essential driver for flows in the Potomac mainstem, this study includes the North Branch for some analytical purposes.

Hydrologic data

- Simulated daily flow time series for a current conditions scenario and for a baseline scenario (for 747 watersheds)
- A broad suite of hydrologic metrics are generated for each time flow series (256 total)
- A selection process is used to select hydrologic metrics which have biotic significance, among other criteria
  - Included metrics for low, medium, and high flows.
  - Did not include seasonal metrics, but that may be included later

Biological data

- Benthic macro-invertebrate data collected from 2000-2008
- Similar metric selection process as for hydrologic metrics, using particular criteria
- biotic metrics reflected diversity (ex- number of taxonomic families), taxonomic diversity (ex- %EPT), pollution tolerance, feeding groups, habitat groups, composite index
- Used macro-invert data at the family level since it was broadly applicable, even though family doesn't predict ecological needs of a species well.
- Some biometrics don't respond differently to watershed size, season, bioregion, while some do sort by these classes (examples shown in her slides 61-62)
- They use classes as a means to explain variation, and let classes emerge from the data.

Flow-ecology relationships

- Mary showed an example graph of High Flow Frequency, calculated by the IHA software, and Ecological status is represented by BIBI score (slides 63-66). It looks messy, but they are getting some relationships. Notice the wide range of IBIs- there are a lot of things contributing to biotic community health. The maximum observed BIBI value decreases as flow alteration increases. It appears, then, that the effect of anthropogenic flow alteration is to limit the maximum possible biology status. A quartile regression was used to identify the 90% maximum and drawing a relationship based on it. There is a decrease in the maximum values of BIBI (benthic index of biotic integrity) with flow alteration.

- The graphs go to stakeholders to decide what an acceptable diminishment of IBI is. For example, for "mean daily fall rate", if a 40% decline in IBI is acceptable, it allows a doubling of the mean daily fall rate.
- www.potomacriver.org

C: Potomac is not modeling the biology, like Michigan did. They are using biologic data, but not modeling it, they are modeling the hydrology. They are using all 'after' data, as compared to before and after data. They modeled as if there had been no alteration and then simulated with altered land cover, withdrawals and any other flow alterations. Using unaltered, the x-axis is modeled, and the y-axis is data.
R: Yes, the x axis is different between the 2 models.
Q: The way they dealt with other stresses besides flow; the assumption is that the dots low on IBI are due to other things? (yes) Maximum IBI is the best they could do with flow alteration. How do you tease out flow effect from other potential stressors?
R: Most places are not able to. Massachusetts takes out impervious surface. [remainder of response inaudible.]

Q: Was there an error analysis in flow modeling confidence? Need high confidence to trust relationships in modeling. In order to be able to trust the relationship you would need a high degree of confidence.
R: Yes, unsure of confidence level. They compared it to gauge data, the R2 of model vs gauge data was >.7 They had a high number of flow gauges.
Mary can look further into it and provide more information.

A 2 page summary of selected case studies of instream flow programs can be found in Appendix A.

3. IF resources for NC and the Southeast region

Southern Instream Flow Research Agenda:

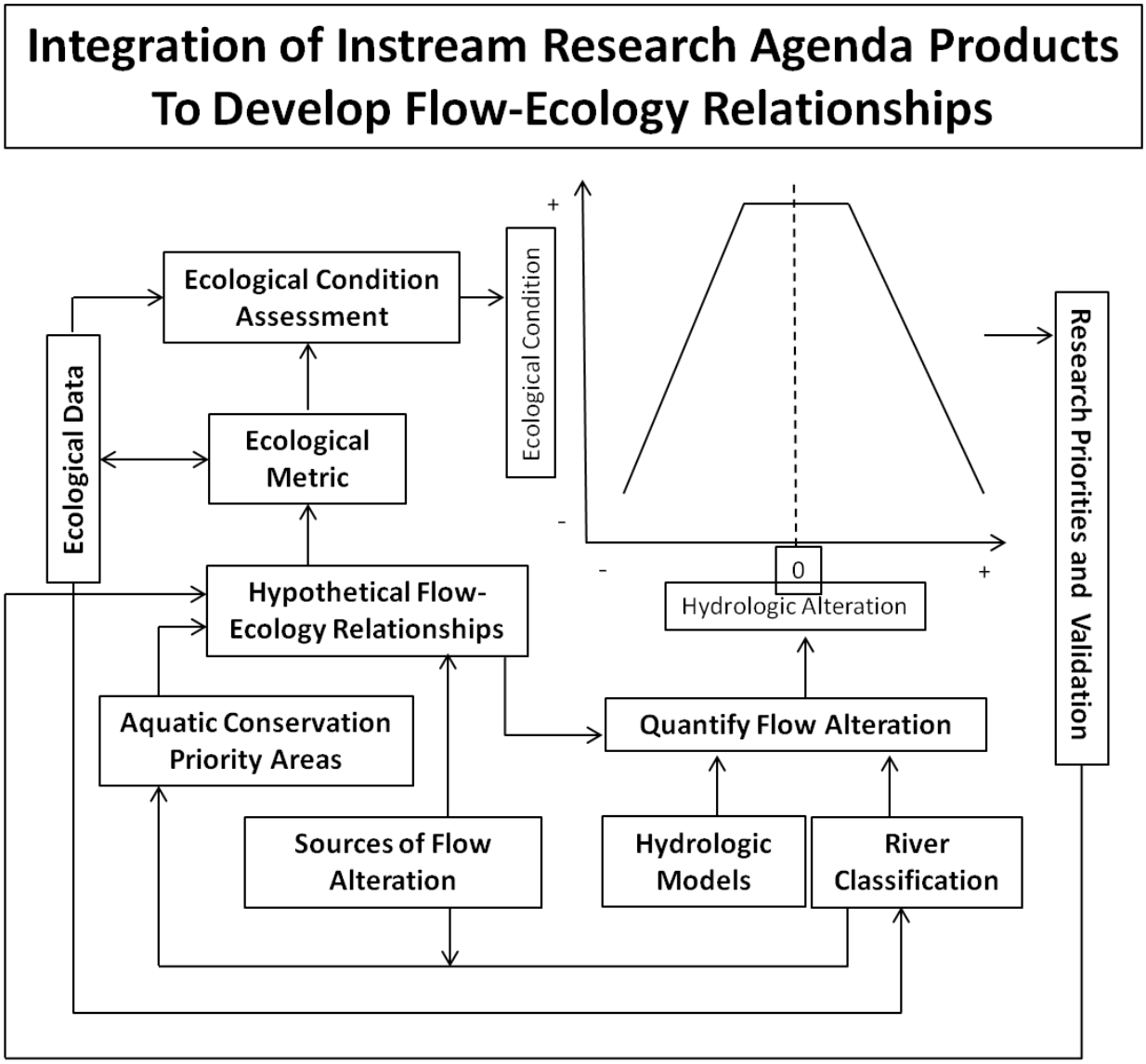
- **Problem:** The limited focus on research and funding for instream flows has resulted in a lack of science to support protective instream flow standards.
- **Objective:** to highlight research needs and coordinate sources of funding and research to address these needs.
- **Goal:** to ensure that instream flow research is focused on the needs of water resource managers for scientifically credible and protective state instream flow standards and practices.

Priority Research Topics

1. Develop a SE regional river classification system
   Drawing on NE river classification. The metrics they had were highly correlated with geomorphologic characteristics, so they were able to classify more broadly than where gauges were.
2. Identify commonalities in ecosystem responses to flow alterations
3. Compile regional aquatic ecology data sets
   - Multistate Aquatic Resources Information System (www.marisdata.org)

- NC will have data available from rivers in other states, extending your analytical powers with more data.

4. Flow Alteration Assessment:
   What is the risk of flow alteration given water consumption, dams, and impervious cover?
   What ecologically significant components of the flow regime are likely to be altered?
5. Perform field studies to test ecological responses to altered flow regimes



In conclusion:

Generally, instream flow science is progressing and is resulting in more protective policies and management practices.

From the case studies:

- River classification works well where there is a clear relationship with biota.
- 'Flow-ecology' relationships help guide selection of hydrologic and biotic metrics
- Demonstrated ecological impairment due to flow alteration provides a strong basis for instream flow criteria.

If we had more time:

- Scientific certainty should be balanced with policy development.
- Presumptive standards may provide a protective option until more studies can be completed.

Q: When we talk about fidelity we have to keep that in mind and it may be that the fidelity is great to basin, or physiographic region or something else, other than class.
R: In that case, do what Michigan did and find the relationship.

C: The Potomac – they had to make assumptions on what they simulated for hydrology; no dams, no withdrawals and 70% forest cover is what they called the base line. If NC went down that road we would have to consider baseline in relation to what the legislation calls baseline.

C: We can always get the legislation changed, which isn't very hard.

R: The US Army Corps of Engineers uses something different for baseline- going back before major impervious surfaces and withdrawals. The NC assumption has been that climate is going to be the same today as it is in the future. Florida uses pre-1970's and post 1970's for the 2 benchmark periods, as there are clearly climate driven changes.

V. Tom Cuffney: Invertebrate traits

Tom Cuffney's Presentation: Invertebrate traits: Compilations of biological characteristics useful for PHABSIM and ecological flow studies

Tom Cuffney's powerpoint is on the EFSAB website: www.ncwater.org/sab

My talk is restricted to invertebrates, though there are compilations of information on fish and algae traits. Traits means characteristics of the species, class, family, etc. includes ecological, morphological, physical traits.

Invertebrate Traits examples (slide): This slide shows a number of example of what there is information on. (examples range from body size, feeding method., substrate preference, etc.)

Two major compilations of traits: Barbour et al. and Vieira et al. and USGS database that is on the web.

Regarding the publication (Vieira et al. 2006 USGS DS-187), USGS in cooperation with universities put together a database on traits. I'll talk about that one.

They used 967 publications, looking at 2,200 species, 1,165 genera, and 249 families. Looked at a variety of traits I mentioned. A lot of info there, it's not a panacea, it is incomplete. I didn't realize how large the table was that I attached to my email. It's a good source.

Relevance to EFSAB and PHABSIM:

I sent out a critique of IFIM from New Zealand (Hudson et al. 2003) for your review; intent was to show there are many technical considerations with doing PHABSIM, particularly how we measure hydrological conditions, and the habitat suitability curves. Purpose is not to bury PHABISM. There is more to do on ecology, DWR has done a good job with the hydro models. From this article: *the greatest single constraint to the proper implementation of IFIM is the habitat suitability curves*. That is a critical point from regarding the ecological part.

Issues to discuss about Habitat Suitability Curves (HSCs):

DWR's work is better than most since you do include invertebrates, this is on the right track. The other thing is use of surrogates (transferability).

Scale: velocity measurements may be appropriate for fish but how do they relate to velocity measurements that may be appropriate for invertebrates, for example one that may live under or on top of a rock?

Taxonomic resolution: HSC curves for different taxonomic levels are not readily available. Velocity and substrate preferences are available for many taxa (species traits). You have to look at it indirectly; you can use trait information. You can look at the velocity and substrate preferences and see how those vary and how they operate at different taxonomic levels.

Surrogates (transferability): Can one species be used to substitute for another species? Data from one river used in another?

Relevance to Session Law

For taxonomic resolution, as an example I pulled together some velocity traits from literature for Ephemeroptera, restricted to species of Ephemoptera we'd likely see in Southeast. Looking at velocity preferences quiet means there is no visible flow, etc. I tabulated if they fit in multiple categories. Looking at species, about 71% fall into one category. At genus level it's about 63%. When you look at family, 81% fall into multiple categories. When you get up to order level you've lost all resolution. This is characteristic - your ability to focus in on traits decreases when you go up in taxonomic hierarchy.

So there is a tension building about how specific you are about the traits of the organism going down to the species level, versus classification of how specific you get for the classification. We need to come to grips with that at some point.

Another example- Caddisfly (Trichoptera): specifically looking at net spinners (2 orders)6 species from same genus and 2 others. Preference for substrate listed. Even within the same genus, the types of habitat they use vary considerable. If you were to use this as an order, genus or family, you would lose the distinctions. For example, one lives on top and filters, one lives under the rock. Even though they have the same habitat preference, the velocity preference is different. Traits allow you to pull additional information about how they react to velocity.

Next example: Functional groups and tolerance:

One genus shown here, tolerance ranges from 0 (very intolerant) up to ~6 (very tolerant). They function in stream the same way (same functional groups) but there is tremendous amount of variability for how much they tolerate disturbance.

So I think we need to talk about whether order is sufficient to represent invertebrate responses to flow. Transferability among streams is low. Order level is not sufficient to represent responses of macro invertebrates to flow. I think we should consider what we're looking at when selecting taxa for HSC studies. Maybe this has been done for fish, but not likely for invertebrates. What surrogates are you going to choose for representing guilds, families, etc. Think about what their traits/characteristics are, whether those things are the types of things that will be affected by changes in flow, so you can focus on group you think will have a high probability that will express changes you think are going to happen.

Regarding Session Law 2010-143 (also referred to as House Bill 1743 before adoption) provides this ecological integrity definition: species composition, diversity, and functional organization.

We haven't focused on composition or diversity. As a group we need to decide if we need to cover all of these or focus on one, what are we actually focusing on?

A simple reminder from my data (slide- Diversity (richness) by community type) number of fish (66), invertebrates (207), algae (249), macrophytes (?) taxa collected under the same spatial scale in NC Piedmont. In terms of diversity of systems, only about 12-14% of organisms are fish, yet that is where most of our time is going. Maybe that's right, maybe it's wrong; we haven't discussed it yet. How much of the community diversity mentioned in the law do we need to deal with, and what is our rationale we're communicating in terms of selection made and what we will focus on?

HSC curves suggestions to improve invertebrates - things were lumped up where we are missing a lot of the important things that distinguish these curves for invertebrates.

Key questions for EFSAB (slide):

- Should quality of the ecological information (HSC) match the quality of the hydrology and habitat characterization?
- Do we examine similar guilds/taxa/functional groups across sites (ignore differences among streams)?
- Do we emphasize the commonalities or the differences? Might lead to transferability issues.
- Examine important guilds/taxa/functional groups in each stream (include differences among streams)?

Last thing is an issue related to transferability, from another New Zealand paper, which looked at one genus of mayfly in 4 New Zealand streams (slide- Inter-stream HSC Transferability). There are 5 curves for velocity, depth, substrate index, they got different curves for same genus. Physical habitat is different, biology is different in these streams. Predator relationships are different. There are a whole range of issues we need to discuss, and we need to communicate clearly how we're dealing with them.

Discussion followed.

Comment (C): There is bigotry about focusing on species we know a lot about. These are whole orders we don't know a lot about. Ex- caddisflys some are restricted, some are statewide. Are there certain ones you'd focus on to see if there are patterns that would match up with hydrologic classifications to understand how it influences abundance?

Response (R): If you have something with an affinity for a particular classification and what about the taxa and the flow conditions leads to organisms being there. Would this be true for fish, bugs, algae?

Q: Tom is the first one to bring up algae and macrophytes. There has been a bigotry towards animals you can see. But it's also an infinite series down to structure of bacteria, viral and fungal

communities, whose species numbers dwarf of those that you showed. All these issues dealing with structure of function groups or species, have a role in what we're doing. To me one of the advantages of the habitat approach we're taking, especially a habitat approach where we're trying to keep it towards the 100% mark, (reference condition) that provides a composite for all of the various species, not only community structure but ecosystem processes. If you minimize alterations to community habitats as a composite, then you're minimizing changes to carbon cycling, nitrogen cycling, decomposition rates. I think that's probably the best approach in maintaining ecologic integrity. I think we need to break away from worrying about what species we will consider and think in terms of the ability to be resilient at an ecosystem.

Tom: Can you get at that without looking at the species?

C: I think you can. To me the HSCs provide a variety of ways to composite information into habitat so we're looking at minimizing alterations to the general condition of that ecosystem. That is my perspective- that is satisfactory.

C: If we can implement a system to minimize change from where we're at, there won't be any issues. But we know that's going to change. An issue is how much change can it take before we get away from intent of session law?

C: Regarding getting to stability - resistance to change, resilience - have to have some yardstick. Usually we're employing some count of species, sometimes just counts of sensitive species.

Patrick pointed out the "Key Questions for EFSAB" and asked if anyone wanted to respond to them.

Q: In regards to the first question, with IFIM we're using those results of hydrology and habitat characteristics that came from site specific information. I see that as the source for our interest in species level information. But I also know in the grand scheme we're lifting IFIM information from a site-specific to a statewide scale, so I'm not sure at what scale the ecology is supposed to be considered. If it's at the site specific level we might not need to look more at species. We're trying to match up site specific stuff to our classification and seeing if that holds true. Do we need to look at species or higher level of taxonomy?

[Response inaudible.]

Jim Mead: It does come down to degree of scale or resolution. At its most specific you're doing an IFIM (or PHABSIM) for a particular project on a particular reach of a particular river. You want to find a degree of resolution so you can come up with specific numbers for that proposal. Our ultimate use of this is that we're going to do it across the state, and not in a way that develops specific numbers for the way this intake operates. It will be specific numbers that may identify a red flag. The red flag means you need to look more into this; in 20 years you may have a problem. It's not to come up with exact prescriptions for a particular project.

Also, with the fish guilds that went into PHABSIM results we've talked about, they are as much an index of physical conditions and how much you're altering acceptable physical conditions, for things that like it deep and fast or shallow and slow for example. By trying to keep within some band of habitat range (80-120% of unaltered is the example we've been using), we say we're trying to keep physical habitat conditions for whatever is out there within a certain band. Our index for that is this habitat number, arrived at from the habitat preference curves (which is shakiest leg of the stool) of how individual species respond to physical alterations. How critical is it for our degree of resolution to know how a particular family or genus will respond if we're looking at a slightly broader index of physical conditions?

Another thing regarding another paper from New Zealand - this author felt PHABSIM microhabitat description is not exactly right. It's true, we're not modeling velocity at the bug at nose level, it's the average column velocity. This other author said it is a level up from micro-

habitat, a sub-meso habitat, in that cell in the average velocity, you were likely to find some things that liked the particular velocity there. You're not modeling velocity at that exact point where the organism is experiencing the flow. It becomes another modeling effort - it becomes 2-3D modeling - velocity at depths of the water column. What degree of resolution do we need?

Comment: If we're wrong about grouping the macroinvertebrates (and they're not even the mussels!), how serious are the consequences? When we're talking about scale, if this is just a red flag regarding nearing over-allocation, there is value in what you are saying. That process of collecting site specific data is ongoing and continuing to go on for each of the permits going forward. Can we talk about the consequences? If we choose a protective Presumptive measure, what are consequences?

C: We'll be wrong some of the time. We run that risk no matter what we do. The emergencies of climate change and increasing demand on rivers requires we take the risk of being wrong some of the time lest we be wrong all of the time. NC is the *only s*tate that does not regulate the withdrawal of water from our streams. If we don't, it seems like our rivers and streams will be severely impaired. What can we get in place relatively quickly and at relatively low cost? What can we give them as a yardstick so they can be right some of the time?

Tom: All I was advocating was that we can do a better job with invertebrates, if people don't think that is required, then that is fine.

C: I want to do a better job with invertebrates ….in each stream.

Tom: You can't track everything, but you can focus on these traits and say what is likely to change when withdrawing more water, can we focus on those in a cost effective way, do we have transferability. Then we start to get something that is more equivalent to what you're doing for fish. That was my point in bringing this up.

C: Early in the discussion of the legislation, those of us in bug world at DWQ pointed out that there was a large difference in definition for protection of biological integrity from pollution standpoint we use when we allocate wastewater permits, compared to the ecological integrity definition. Clearly what jumps out to me is not the reliance on biological integrity (reference conditions like identified species and ecology) but rather bottom line of this legislation which is maintenance of good and services. If we had the luxury of time and incorporating the wisdom Tom shared on use of other indicators, we should do that. Short of that, I have to support what Sam says. We only have so much time before we have to make recommendations on how to deal with minimum flows to maintain our fish and biology. Whether we have recommendations to DENR or whether DWR proposes a new focus for SAB, I think we have both a long term and short term recommendations.

C: 2 points:

1. Better articulation of taxa - does it change the results at the scale we're working on? That is a testable exercise. You could probably help Jim develop those curves and fit them in to see if it changes overall patterns he's been getting.
2. Regarding the red flag issue that was just raised - maybe we need to spend more time talking about whether 20% or 10% is the number for a presumptive standard. If that's what we're doing, setting up a trigger mechanism for whether more intense work needs to be done. That might be a good use of our time.

Jim: Would be good to discuss the presumptive standard idea after Steve's presentation. If there is a preference curve for long lived net spinners that can be developed quickly, I'd love to model and see if it would be different. We could also take the 3 EPT curves we have and cartoon them in, to see how different is the composite result if we erred above and below a certain amount.

C: With any of the curves, take the names off, does the suite of curves represent the habitat conditions out there, whether we call it x, y, z may not matter. Another way to do it, I'm not sure

if everyone has been given all of the curves? We could provide all the curves. We're using mean column velocity, depth, and what does it mean for the critter down here or the top feeder. That's another way to maybe get at this instead of doing a sensitivity analysis. How much does it change the outcome?

The group decided to hear Steve Reed's presentation before discussing any further.

VI. Steve Reed: How Ecological Flows Would be Applied to NC River Basin Models

Steve Reed of the NC Division of Water Resources presented slides that are available on the website at: www.ncwater.org/sab

Much of this presentation comes from the session law, which requires river basin models that include ecological flows and instances when ecological flows may be affected. Currently, NC doesn't have ecological flows included in our river basin models. If not included, models assume any and ALL water can be withdrawn to meet demands.

This instream flow model would be used as a screening tool for river basin models & plans. It would flag locations where offstream demands and instream ecological flow needs cannot be met under existing or projected conditions. It needs to be quantified at ALL nodes of interest throughout each basin. We may need to go back to discuss what the law says about prevailing conditions and how we will interpret that.

River basin models include:

- Unaltered Hydrology
- Flow Alterations – withdrawals, discharges, reservoirs
- Withdrawals include existing, 20- and 50-year projections
- Nodes – specific locations where records of flows are simulated

Nodes are places where the model is going to be making the calculation and where flow calculations will be determined, where an ecological flow may be adversely affected.

Anywhere water is coming out or going back into the stream, we have a node (anywhere it is over 100,000 gallons)

Each node has data for:

- Drainage Area
- Daily Flows for 80 years – unaltered, existing, 20-year, & 50-year projections
- But, not data for ecological flow

For example, when the model is run and the ecological flow is added in, it might raise a red flag at some node, which would tell you to go in and check it out and further evaluate what is going on.

Question: this makes sense to me if there is minimum flow, but how does it work when you have more of a natural range of variability, such as being sure there are high range events and low range events, all of which are natural.

[Inaudible response]

Current number of nodes:

- Neuse = 84
- Cape Fear = 164
- Tar = 21
- Broad = 40
- Plus 13 more basins, eventually

Q: Is the model dynamic enough? For example, in the Neuse a third may be one type of classification and another 3rd another type. Is the model going to be able to handle that?

Response: Short answer is yes.

The Task:

- How will the ecological flow be quantified at each node?
- Is the approach for determining the ecological flow the same for all nodes?
- If not, how are we subdividing nodes?
- What are the stream classifications?
- How many different approaches/ classifications are there?

Comment: We need to consider all things, including having minimum flows versus having precise ecological flows.

C: Some things happening at some nodes are 30 years old, so they may actually represent a violation, so do we put the entire onus on the new withdrawal or do we decide to look at prior users.

Steve: Basically, it's a flag that will go up, and then we make decisions at that point.

C: It has been helpful to hear this presentation because it gets us back to thinking about what we are supposed to be doing.

C: This is the science process.

C: DWR suggested a 2 year mission and I think we need a midcourse identification to see if we are on the right path. Currently it has been an internal education process, which has been good, but now maybe we need to know what the division needs to move us forward.

C: Until something comes from the board, there is nothing to put into the models. So the sooner we can get something in, the sooner we may all be happy.

R: Whatever you come up with, we can put it into a model.

C: If a municipality or an industry is withdrawing water, that is difficult to change. But what we need to do is come up with a range of flows for those streams.

C: Can we put in a presumptive standard, go for it, and check with us in 2 years?

C: The legislation seems to say that would be OK to put in a stopgap measure.

C: I don't want to move to far without having the DENR input.

C: Looking at Mary Davis' handout, those are multiyear projects, and I don't see the board doing all that. Do we need to have something in place now? Or do we have the flexibility to look at multi-year approaches that other states are using. I don't know what the pressure is on DWR.

C: The Nature Conservancy is working with RTI and starting a one year project to do a study like the Potomac project for 3 watersheds in NC in this coming calendar year, basically the ELOHA approach. NC is doing the Michigan approach basically. So we will have a lot more data soon, almost within the 2 year schedule for this group. There's nothing that says our schedule can't be extended.

Q: It seems the idea of putting in a presumptive standard got raised eyebrows from the DWR staff. What would DWR do with a presumptive standard if we decided on one now? Would it help us to move forward?

Q: What does DWR think about it?

C: What I am hearing is there is a lot of work for the SAB, with not a lot of funding, so we need to balance expectations with what we are likely able to achieve. Can you get back to us at the next meeting about what DWR needs?

DWR: DWR can report back on this in January.

C: EMC has to approve all models

C: We can get it nailed down, it is thorny, but we can do it. We need some firm objectives.

C: 3 things may occur that the model is supposed to produce:

1. To identify the yield inadequate to meet all needs
2. To identify the yield inadequate to meet all essential water uses
3. To identify the yield when ecological flow may be adversely affected.

I think I understand 1 and 3, but I want to know what the essential uses are. How is that being defined?
Can we run this scenario through one or more of these basin models to see when these things occur so we can better understand all of this.

C: I was there when those 3 identifiers above were written. The goal was to find all needs, pollution dilution, and ecological integrity. Pollution dilution was converted to 'essential needs" to meet legal requirements. It is important to remember – the legislature doesn't work with models, and they don't have a requirement that it be one model, it could be a number of models working in tandem. It may be easier to solve this problem that looks at output from OASIS instead of input. We can be totally flexible. I don't think we have to test ecological integrity at every node in every model. Maybe we can look at the lowpoint node along a stream. We don't need to make this more complicated than it has to be. We should strive to make this more straightforward instead of more complex.

C: Whatever algorithm we come up with, it will apply to all the nodes.

C: I'm not talking about how it applies, what I'm saying is that you may not have to run the model at every node. Maybe we can just run the model where you have change in classification.

I think you want to do it at each of these nodes, to determine which node or which withdrawal it stems from or is it the culmination of all the withdrawals.

C: But you then transfer the responsibility to someone down the line to make a decision.

C: It sounds like there is already a presumptive standard, which is 7Q10 – is that true?

C: Well, that is the water quality standard.

C: We need to get some presumptive standard into the model and then move up from there.

C: I'm trying to understand what the House bill expects each basin wide model to determine and what output is required. Those 3 categories above (essential water uses, etc.) seem to overlap.

C: All uses is all encompassing. When that was decided there were champions for each number or category, but rather than try to find something that satisfied all 3 interests, it was decided to come up with those 3 overlapping categories.

C: We have the Cape Fear and the Neuse model. The Tar and the Broad are close to being done. They are ready to run, but they haven't been run yet.

C: Can we stick in a place holder, for example, 15%, to help us understand the output of the model?
R: Currently we don't have those 3 categories in the models; we don't have any flow put in there (eco flows). We are waiting on you, the EFSAB to tell us something. It does not have to be 7Q10. If you tell us to test it with a protective standard we will. Essential use is the first thing defined, we don't have it yet, neither have we taken it to EMC.

C: We've already experienced people using water during drought where we've gone below the 7Q10.

C: It would be easy to plug 7Q10 or 10% of inflow as a presumptive standard, into OASIS and test a new node by taking some water out. That seems pretty straight forward. That will get us some temporary info, but at some point we need to be much better than that. That's the reason we are here, isn't it?

C: Ecological integrity is somewhere in between the 3 categories, and 7Q10 is probably the lowest.

VII. Agenda discussion for next meeting

For the next meeting we have Mary Freeman coming from USGS. We asked her to talk about general stream ecology, specifically in the southeast and using the ACF basin, and transferability of species preferences.

C: I'm interested in the defensibility of their methods in that basin. Three states are in disagreement and I'd like to know how Mary thinks it's going to work out.

C: What about discussing the 'better' taxa to use that Tom mentioned. We barely scraped the surface of that.

C: It would be good if Mary could discuss some of what was done in the Flint.

We have time scheduled for more discussion of the biological aspects of ecological flow.

C: It's becoming increasing clear that we need to take the classes we have, and subdivide them to find classes that have a high degree of biological fidelity, and for each of the new classes, identify indicator species that are especially sensitive to the flow metrics for each class. We are not very far from being able to do that. We seem to be close to doing that by just taking a few more steps. Is there any reason that wouldn't work?

There has been discussion and disagreement about the EFSAB charge. Can we have a discussion about the charge? What are your ideas about that?

C: What are DWR's expectations for the group?

C: I'm not confused about that, is anyone confused about that?

C: I am a little bit confused, in terms of bringing the best science versus bringing something to fruition within the time frame that is needed. We can't plan out 10 years of research and also get it done in 6 months.

C: If the consequence of getting it done perfect is that we don't get anything done in time, then that is a problem.

C: Let's hold that till February so that it doesn't cut into our biological discussion time.

C: We have been asked to take 2 years and advise the department. Maybe the best way to do that is to take further time to clarify.

C: You can have fast, cheap or accurate, you can't have all 3.

C: The legislation doesn't have a deadline. To not decide, is to decide.